galactic latitude $-3°$. With the addition of the data for Messier 11 and for the four neighboring fields, it appears that the redness of the faint stars will be found to depend, as might be expected, upon galactic latitude, and in the mid-galactic regions will vary with the density of the star clouds.

6. The presence of negative color indices for faint stars in the three widely separated galactic regions mentioned above shows that, if these stars are typical in absolute brightness, the dimensions of the galactic system in the plane of the Milky Way are many times greater than has been inferred from studies of variables and investigations of the motions and magnitudes of the brighter stars.

[1] For instance, see Parkhurst, Yerkes Actinometry, *Astroph. J., Chicago, Ill.*, **36**, 1912, (218, 225) and figure 5 on p. 56 of *Mt. Wilson Contrib.*, No. 116.

[2] *Berkeley, Univ. Cal. Pub., Lick Obs.* **11**, 1913, Plate 62.

[3] *Mt. Wilson Contrib.*, No. 116, 1915, (81 ff.).

[4] These PROCEEDINGS, **2**, 1916, (12–15).

[5] *Astroph. J., Chicago, Ill.*, **39**, 1914, (361–369); [*Mt. Wilson Contrib.*, No. 81].

[6] *Ibid.*, **42**, 1915, (92–119); [*Mt. Wilson Contrib.*, No. 100].

[7] *Ibid.*, **42**, 1915, (120–132); [*Mt. Wilson Contrib.*, No. 102].

[8] *Mt. Wilson Contrib.*, No. 117, 1916. The unpublished results for the fields near Messier 13 are provisional.

[9] In N. G. C. 1647 Hertzsprung (*loc. cit.*) finds one star of photographic magnitude 12.40 that is apparently of spectral type B.

[10] *Astroph. J., Chicago, Ill.*, **42**, 1915 (148–162); [*Mt. Wilson Contrib.*, No. 104].

THE COLOR OF THE STANDARD POLAR STARS DETERMINED BY THE METHOD OF EXPOSURE-RATIOS

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An earlier note in these PROCEEDINGS describes a method of measuring the color of a star which depends upon the ratio of the exposure times necessary for its blue and yellow light to produce images of the same size.[1] A comparison of the observed exposure-ratio with a curve derived by combining similar ratios for stars of known color affords a means of expressing the results in terms of color-index or color-class.

The method is expeditious, and, under favorable conditions, precise; it is entirely independent of stellar magnitudes, and hence avoids the systematic errors which so easily enter as a result of uncertainties in the magnitude scales or in their zero points. Moreover, the method is direct, in the sense that color is measured and not inferred from observations of spectral type. The results thus include that part of the color

which is a function of the star's intrinsic luminosity and also the influence of a possible scattering of light in its passage through space.

The following paragraphs indicate briefly the results found with the 60-inch reflector for about 80 of the North Polar Standards between magnitudes 2.5 and 16.3 whose colors had already been derived by a comparison of their photographic and photovisual magnitudes. The brighter stars, owing to their distribution, had to be observed separately. To avoid photographic difficulties, the plates for these were all of the same emulsion. Further, all the brighter objects were reduced to an equivalent of the 11th magnitude, approximately, by means of screens and diaphragms and then given the following series of exposures on a Cramer Inst. Isochromatic plate:

a. Yellow images (through yellow filter), 16^s, 32^s.

b. Blue images (without filter), 2^s, 4^s, 8^s, 16^s, 32^s.

c. Yellow images (through yellow filter), 16^s, 32^s.

In a few cases the exposures for the yellow images were 32^s and 64^s.

The data on each plate were reduced graphically and gave two values for the exposure-ratio corresponding to equal blue and yellow images. In general, three plates, exposed upon different nights, were used for each star. To derive a reduction curve connecting color-index with exposure-ratio, the mean ratios were collected in groups according to color-index. Since each group contains stars of widely differing magnitudes, the resulting curve is probably free from the influence of any systematic error in the color-indices depending on brightness, and should give a reliable value for the color of any star whose exposure-ratio has been determined under conditions similar to those underlying the derivation of the curve itself. Moreover, the question of systematic errors in the original color-indices, which were taken from the Mount Wilson investigation of the photographic and photovisual magnitudes of the polar stars, can be put to a direct test.

For this purpose the color-index of each star was determined from its exposure-ratio by means of the reduction curve and compared with the original value based on magnitudes. The differences, arranged according to the brightness of the stars, should reveal any systematic error in the original system of color values, and thus test the accuracy, relative to each other, of the photographic and photovisual scales of the North Polar Standards. The means of these differences for groups of stars of a limited range of brightness are given in the second column of the table. Obviously there are no systematic differences of any importance which depend upon magnitude.

In order that the investigation might be extended to the fainter stars,

five additional photographs were made with single yellow exposures of 128^s and 10^m, respectively, and corresponding blue exposures of 8^s, 16^s, 32^s, 64^s, and 1^m, 2^m, 4^m. For these the full aperture of 60 inches was used, and the measurable images of all the stars shown were included in the discussion. On the plates of the first series described above, the images for objects of all degrees of brightness were approximately of the same size; but here there was no attempt at equalization.

The question as to the effect of size of image upon the exposure-ratio had accordingly to be examined. Inasmuch as the gradation of a photographic plate is to some extent a function of the wave-length of the light producing the image, the necessity for some correction of the exposure-ratios derived from these plates of longer exposure was anticipated. Special photographs of bright stars taken with a wide range in aperture, but with the same series of exposure times, gave data for a provisional determination of the corrections. These seem to be moderate, unless the images used for finding the exposure-ratio are very large. The corrected mean differences are in the third and fourth columns of the table. The two plates of 10^m exposure were of another emulsion, requiring a different reduction curve, and were accordingly reduced to the standard curve which applies to the remainder of the data.

Finally, an additional group of four plates of the original emulsion was exposed in November, four months after the others had been taken. The results for these are in the fifth column of the table. As the small correction depending on the size of the image is not yet well determined, it has been omitted in the case of this last group of plates. It will be noted that the results are substantially as before.

DIFFERENCE BETWEEN COLOR-INDEX FROM MAGNITUDES AND THAT FROM EXPOSURE-RATIO

(Unit = 0.01 mag.; number of values in parentheses)

PHOTOGRAPHIC MAGNITUDES	DURATION YELLOW EXPOSURES				WEIGHTED MEAN DIFFERENCE	NUMBER OF STARS IN GROUP
	$16, 32^s$	128^s	10^m	16^s to 8.5^m		
3.5	0(12)				0	2
5.7	+3(16)				+3	3
6.5	−2(20)				−2	4
7.5	+2(20)				+2	3
8.6	−3(24)				−3	3
9.4	−7(18)				−7	3
10.6	−4(48)				−4	6
11.4	+5(54)	+5(24)	+4(14)	−5(23)	+3	8
12.3	+2(4)	+3(15)		−5(15)	−1	7
13.3		+6(25)	+1(17)	+4(25)	+4	12
14.1		0(5)	+3(26)	−5(7)	+1	13
14.8			0(26)		0	13
15.5			−6(21)	+7(6)	−3	11

The last two columns of the table give the weighted mean differences between the Mount Wilson color-indices and the color-values derived from the exposure-ratios, and the number of stars included in each group.

The close agreement in the two series of results shows clearly enough the usefulness of the exposure-ratio method, and indicates that the photographic and photovisual magnitude scales for the North Polar Standards are substantially in the proper relation to each other. The agreement affords no test of the presence of errors affecting the two scales equally; but there can be no important divergence of either scale relative to the other, for the differences in the color-values derived by the two methods would then show a progressive change with magnitude.

In general, the precision of the method of exposure-ratios is excellent. For example, the probable error of a color-index derived from a single exposure-ratio is about 0.07 magnitudes. This value is based upon the results for the 36 stars for which there are five or more separate determinations, and speaks well for the uniformity of different plates of the same emulsion. Puzzling abnormalities have occasionally occurred, but the cases thus far met with are perhaps to be attributed to causes external to the plates themselves. Each emulsion will undoubtedly require a special investigation for the determination of factors which will reduce it to the standard curve connecting exposure-ratio and color-index, but this should not be a matter of any great difficulty. Nevertheless, the limitations of the method can not be fixed until a number of questions of this sort have been examined.

In the meantime, however, it may be noted that the colors of the Polar Standards, brighter than the 13th magnitude, have been determined to about the same precision as was reached in the investigation of the magnitude scales, with an expenditure of time and labor which was perhaps a tenth of that required for the earlier investigation. All of the observational data for the present investigation, including about 80 photographs and nearly 400 separate determinations of color, were obtained during three nights with a total of less than 22 hours observing time.

One of the most interesting consequences of this recent determination of the colors of stars near the Pole is to be found in the confirmation it affords of a result previously announced,[2] namely, that there are no faint stars in this region with negative or small positive color-indices. The lower limit of the color-index gradually increases as the fainter stars are approached, and at the 16th photographic magnitude its value is of the order of +0.5 magnitude. Although this state of affairs was

indicated with some certainty by the comparison of photographic and photovisual magnitudes, it is of interest to find it appearing as the result of an entirely different method of investigation.

The absence of faint white stars is known to be a characteristic of other regions as well,[3] but it must not be inferred that such objects are not to be found anywhere in the sky. In Selected Area No. 88, for example, in one of the outlying clouds of the Milky Way, photographs by the exposure-ratio method indicate that the stars of the 14th or 15th magnitude are nearly normal in color and thus include a considerable number of objects that are white. Mr. Shapley has also accumulated evidence of this sort in connection with his study of clusters.

[1] These PROCEEDINGS **2**, 1916, (521–525).

[2] *Astroph. J., Chicago, Ill.*, **39**, 1914, (361–369); [*Mt. Wilson Contrib.*, No. 81].

[3] *Ibid.*, **40**, 1914, (187–204), **42**, 1915, (92–119), (120–132); [*Mt. Wilson Contrib.*, Nos. 83, 100, 102].

TERRACING OF BAJADA BELTS

By Charles Keyes

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For the local stream-trenching and the resultant terracing of the higher zones of those long uniform slopes which so often spread out from the foot of desert mountain ranges there is an explanation very much simpler than any of the numerous ones yet offered. It has the advantage of being in strict accord with the regular and ordinary phases of erosional action which recent critical observation shows to be now at work as vigorously and as effectively as they have been in any past period. It is, in effect, nothing more than a reiteration, in a somewhat new form to be sure, of the old law of parsimony which forbids the unnecessary multiplication of explanatory elements and agencies.

In all late physiographical writings in which the term bajada is used it is unfortunately misconstrued. Spanish-speaking Americans do not seem ever to have given the title so broad a meaning as that sometimes attached to it. If the name is to remain a useful geographical term of description it should be allowed to retain something of its original significance, and should be restricted in its application to the steeper slopes of the desert piedmonts. Without exception bolsons appear to present four distinct physiographic areas, or belts, three of which are plains. There is the central, more or less level tract, sometimes covered for a period of a few days or weeks of each year by a